EFFECT OF OPERATIVE VOLUME ON MORBIDITY, MORTALITY, AND HOSPITAL USE AFTER ESOPHAGECTOMY FOR CANCER

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Objective: We sought to evaluate the effect of operative volume, hospital size, and cancer specialization on morbidity, mortality, and hospital use after esophagectomy for cancer.

Methods: Data derived from the Health Care Utilization Project was used to evaluate all Medicare-reimbursed esophagectomies for treatment of cancer from 1994 to 1996 in 13 national cancer institutions and 88 community hospitals. The complications of care, length of stay, hospital charges, and mortality were assessed according to hospital size (≥600 beds vs <600 beds), cancer specialization (national cancer institution vs community hospital), and operative volume (esophageal [≥5 Medicare esophagectomies per year vs <5 Medicare esophagectomies per year] and nonesophageal operations [≥3333 cases per year vs <3333 cases per year]).

Results: Mortality was lower in national cancer institution hospitals (4.2% [confidence interval, 2.0%-6.4%] vs 13.3% [confidence interval, 4.2%-26.2%], $P = .05$) and in hospitals performing a large number of esophagectomies (3.0% [confidence interval, 0.09%-5.1%] vs 12.2% [confidence interval, 4.5%-19.8%], $P < .05$). Multivariate analysis revealed that the independent risk factor for operative mortality was the volume of esophagectomies performed (odds ratio, 3.97; $P = .03$) and not the number of nonesophageal operations, hospital size, or cancer specialization. Hospitals performing a large number of esophagectomies also showed a tendency toward decreased complications (55% vs 68%, $P = .06$), decreased length of stay (14.7 days vs 17.7 days, $P = .006$), and decreased charges ($39,867 vs $62,094, $P < .005$).

Conclusions: These results demonstrate improved outcomes and decreased hospital use in hospitals that perform a large number of esophagectomies and support the concept of tertiary referral centers for such complex oncologic procedures as esophagectomies. (J Thorac Cardiovasc Surg 2000;119:1126-34)

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Read at the Twenty-fifth Annual Meeting of The Western Thoracic Surgical Association, Olympic Valley (Lake Tahoe), Calif, June 23-26, 1999.

Received for publication June 29, 1999; revisions requested Sept 15, 1999; revisions received Dec 20, 1999; accepted for publication Jan 10, 2000.

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0022-5223/2000 $12.00 + 0 **12/6/105644**
doi:10.1067/mtc.2000.105644

Esophagogastrectomy is one of the most complex surgical procedures performed and therefore has the potential for high morbidity and mortality rates.[1-3] Over the past 30 years, there have been significant improvements in perioperative management and techniques that have led to decreases in both morbidity and mortality rates for elective esophageal resection.[4] In addition, several studies have documented decreased mortality when complex oncologic procedures, such as pancreatectomy or liver resection, are performed in high-volume referral centers.[5-8] Analysis of a Medicare-linked database by Begg and colleagues[9] revealed a significantly decreased operative mortality when pancreatectomy, liver resection, pelvic exenteration, or esophagectomy was performed in an experienced high-volume

center.[9] This study did not, however, evaluate the effect on hospital use or the role of other hospital factors, such as cancer specialization (national cancer institution vs community hospital), hospital size, or volume of nonesophageal operations. We therefore reviewed Medicare-reimbursed esophagectomies from data provided by the Health Care Financing Administration by means of Inforum, the subsidiary of the Medstat Group, to determine which hospital factors were most closely related to short-term outcome and hospital use after esophageal resection for cancer.

Material and methods

Medstat's severity-adjustment methodology, developed with national Health Care Utilization Project (HCUP) data, was used to evaluate all Medicare-reimbursed esophagectomies for cancer from 1994 to 1996 in 13 national cancer institutes and 88 community hospitals. Selection criteria for esophagectomies were based on International Classification of Diseases, ninth edition (ICD-9), procedure and diagnosis codes. Patients with malignant disease of the esophagus were selected, excluding those with oral or pharyngeal tumors. The total operative volume of each hospital was obtained in a similar manner, searching for all major surgical procedure codes.

For the purpose of analysis, hospitals were assessed according to various factors: esophageal operative volume (≥5 cases per year vs <5 cases per year), total operative volume (≥3333 cases per year vs <3333 cases per year), bed size (≥600 beds vs <600 beds), and cancer specialization (national cancer institution vs community hospital). The factors were divided when possible by balancing the number of patients and hospitals in each category. National cancer institution versus community hospitals were divided arbitrarily by category. Data assessed included sex, age, location of tumor, type of procedure, operative mortality, complications of care, length of stay, and hospital charges. Actual data and severity-adjusted data were analyzed. Severity-adjusted data were obtained from Inforum Outcomes Analyst, a subsidiary of the Medstat Group (Nashville, Tenn). All severity-adjusted values were calculated from algorithms developed from a 10 million–patient database obtained from the National HCUP survey. These algorithms provided expected values depending on the individual patient's age, principal diagnosis, sex, admission type, and comorbidities.

Statistical analysis was performed on actual and severity-adjusted data. Differences between the variables were tested for significance by means of the χ^2 analysis for categoric variables and the Student *t* test for continuous variables. Charge and length of stay data were analyzed after log transformation to adjust for skewness. The final data were retransformed for presentation clarity and clinical relevance. Severity-adjusted data were assessed by using analysis with population variances provided by Inforum and with resultant 95% confidence intervals (CIs) assessed for statistical significance at the .05 level. This method did not provide exact *P* values for nonsignificant data in the severity-adjusted data. To remain consistent, all *P* values in the figure, including analyses not related to severity-adjusted data, were represented as not significant if the *P* value was less than .05. Multivariate analysis for the mortality data was performed by logistic regression, and analysis of hospital charge data was performed by using linear regression. Multivariate analysis was performed on all variables that we believed had prognostic or clinical relevance. Statistical packages used included SPSS (SPSS Inc, Chicago, Ill) and Inforum's Outcomes Analyst II (Inforum).

Table I. *Characteristics of patients undergoing esophageal resection for cancer*

Characteristic	*No. of patients*	*%*
Sex		
Male	265	78
Female	75	22
Location of tumor		
Cervical esophagus	6	2
Upper esophagus	17	5
Middle esophagus	38	11
Lower esophagus	227	67
Not otherwise specified	52	15
Procedure		
Total esophagectomy*	133	39
Partial esophagectomy*	196	58
Not otherwise specified	11	3
Total patients	340	

*Total esophagectomy is defined as transhiatal esophagectomy or total transthoracic esophagectomy (ie, cervical anastomosis), and partial esophagectomy is defined as right (Ivor Lewis) or left transthoracic esophagectomy (ie, thoracic anastomosis).

Results

Characteristics of patients undergoing esophageal resection. A total of 340 patients were identified who underwent esophageal resection for cancer in 25 hospitals. Patients with pharyngeal and oral tumors were excluded to provide a more homogeneous group of patients. As shown in Table I, the majority (265 [78%]) of patients were male, with an average age of 70.4 ± 6.9 years. The lower esophagus was the predominant location with 227 (67%) patients. A total of 196 (58%) patients underwent a partial esophagectomy (ie, Ivor Lewis type [right transthoracic] or left transthoracic) with a chest anastomosis, and 133 (39%) patients underwent a total esophagectomy (transhiatal or 3-field esophagectomy) with a cervical anastomosis. In 11 (3%) patients the type of esophagectomy was not specified. No differences could be noted between types of hospitals (ie, cancer specialization, hospital size, or operative volume) according to age, sex, or location of tumor (data not shown). Some variation was noted between hospitals and type of procedure, with a higher

Table II. *Mortality and complication of care with and without risk stratification in patient undergoing esophageal resection for cancer according to operative volume, hospital size, and cancer specialization*

	No. of hospitals	*Patients*	*Actual mortality**	*Actual mortality/ expected mortality†‡*	*Actual complications of care**	*Actual complications of care/expected complications of care†‡*
Cancer specialization						
National cancer institutions	12	310	13 (4.2%)	0.33 (0.26–0.45)	176 (57%)	2.25 (1.89–2.79)
Community hospitals	13	30	4 (13.3%)	1.01 (0.54–7.63)	21 (70%)	2.66 (1.67–6.61)
P value			.05	<.05	NS	NS
Esophagectomy volume						
≥5 cases/y	5	266	8 (3.0%)	0.23 (0.19–0.33)	147 (55%)	2.18 (1.81–2.75)
<5 cases/y	20	74	9 (12.2%)	0.97 (0.63–2.14)	50 (68%)	2.68 (1.93–4.40)
P value			.004	<.05	.06	NS
Total operative volume						
≥3333 cases/y	10	263	12 (4.6%)	0.37 (0.29–0.53)	150 (57%)	2.25 (1.86–2.83)
<3333 cases/y	15	77	5 (6.5%)	0.48 (0.32–0.98)	47 (61%)	2.44 (1.76–3.98)
P value			NS	NS	NS	NS
Hospital size						
≥600 beds	12	176	12 (6.8%)	0.62 (0.44–1.02)	104 (59%)	2.31 (1.85–3.09)
<600 beds	13	164	5 (3.0%)	0.21 (0.16–0.32)	93 (57%)	2.27 (1.79–3.08)
P value			NS	<.05	NS	NS

NS, Not significant.
*Number of patients, with percentage in parentheses.
†Mean with upper and lower 95% CI in parentheses.
‡Ratio of actual mortality or complication/expected mortality or complication obtained by using expected outcomes developed from the 10 million–patient database of the National HCUP survey.

Table III. *Multivariate analysis of operative mortality in hospitals according to operative volume, hospital size, or cancer specialization*

Hospital factors	*Odds ratio*	*CIs*	P *value*
Mortality			
Cancer specialization (community hospitals)	0.98	0.23–4.26	.98
Esophagectomy volume (<5 cases/y)	3.97	1.14–13.84	.03
Total operative volume (<3333 cases/y)	1.96	0.32–12.3	.47
Hospital size (<600 beds)	0.25	0.05–1.31	.10

percentage of partial esophagectomies in national cancer institutions and high-volume operative centers (data not shown).

Mortality and complications of care according to hospital type. The majority of patients tended to be operated on in national cancer institutions (310 patients [91%]) and high-volume (>5 esophagectomies per year, 266 patients [78%]) operative centers (Table II), although the number of hospitals was evenly distributed between groups. Operative mortality and complications of care were assessed either as actual data or as severity-adjusted data in which an index was created of actual over expected outcome. In both actual and severity-adjusted data, mortality was significantly reduced in national cancer institution hospitals (4.2% [CI, 2.0%-6.4%] vs 13.3% [CI, 4.2%-26.2%], $P < .05$) and hospitals that performed a large number of esophagectomies (3.0% [CI, 0.09%-5.1%] vs 12.2% [CI, 4.5%-19.8%], $P = .004$). Severity-adjusted data also suggested that small hospitals (<600 beds) had a lower than expected mortality index when corrected for associated comorbidities (0.21 vs 0.62, $P < .05$). A multivariate analysis was therefore performed to try to assess the independent risk factor for mortality (Table III). In this analysis the volume of esophageal operations performed was the only significant risk factor (odds ratio, 3.97; $P = .03$) and not the volume of nonesophageal operations, cancer specialization, or the size of the hospital. Because we had noted a difference in the type of surgical procedure performed (ie, total vs partial esophagectomy) between groups, we included this variable in our univariate and multivariate analysis and found no relationship (odds ratio, 0.86; $P = .81$). Fig 1 depicts the linear relationship between hospital esophageal operative volume and mortality. This analysis shows that the majority of hospitals fall into the category of low-volume centers. Analysis by continuous variables is limited by the large gap between high- and

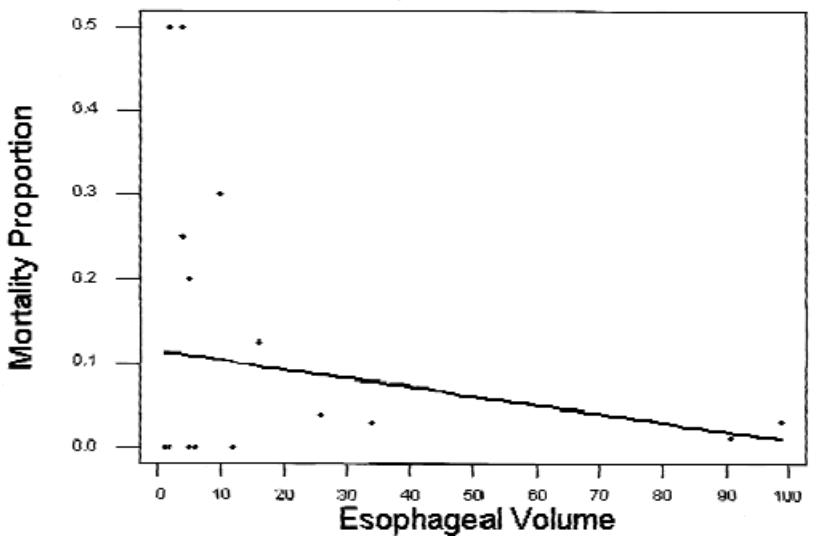

Fig 1. Analysis of operative mortality versus hospital esophageal operative volume over the 3-year study period. The regression equation is as follows: y = 0.113 – 0.00083x (*P* = .47).

low-volume centers and the small number of patients available for analysis because of the relative rarity of the disease.

There also appeared to be a trend toward decreased complications of care in hospitals that performed a high volume of esophageal operations (55% vs 68%, *P* = .06) that was not present in the other hospitals, although these results were not seen in the severity-adjusted data. These results suggest that the major independent risk factor for short-term outcome after esophageal resection is the number of esophagectomies performed in the hospital and not the amount of nonesophageal operations, cancer specialization, or hospital size.

Hospital use according to hospital type. Length of stay and hospital charges were evaluated according to hospital type (Table IV). The data were assessed as actual data or severity adjusted by subtracting the actual from the expected outcome. There appeared to be significant differences in hospital charges according to hospital type, with lower charges noted in national cancer institution hospitals, high-volume operative (esophageal or nonesophageal operations) hospitals, and those with a larger number of beds. Severity-adjusted data showed that the difference between expected and actual charges was substantially less in national cancer institution hospitals and those performing a large number of esophageal or nonesophageal operations, indicating better management of resources. A multivariate analysis was therefore performed and revealed that the most significant independent risk factor for hospital charges was the volume of esophageal operations (β = 1.42, *P* < .003) and the hospital size (β = 1.29, *P* < .002).

Assessment of length of stay suggested a difference according to hospital type when the actual data were assessed but no difference when severity-adjusted data were evaluated. These results suggest again that the most important predictor of decreased hospital use is esophagectomy volume and not cancer specialization or volume of nonesophageal operations.

Discussion

Morbidity and mortality rates have decreased dramatically over time for esophagectomies performed for cancer. The mortality rates have dropped from 12% in the 1970s and early 1980s to 3% in the late 1980s and early 1990s.[4] Furthermore, the number of complications has decreased from 72% to 60%, with a resultant decrease in hospital use because of a drop in the number of days needed to treat resultant complications. The exact factors in this improvement in short-term outcome and hospital use are not clear but may be multifactorial. One component is surgical expertise because a large amount of data suggests that morbidity and mortality can be decreased in complex surgical procedures with experience. This is true in pancreatectomies, liver resections, lung resections, and colorectal operations.[5-7,10-12] Evidence exists that mortality rates are reduced for surgeons who perform more of these procedures. Another component, however, is the improved perioperative care and patient selection that has come

Table IV. *Hospital use with and without risk stratification in patients undergoing esophageal resection for cancer according to operative volume, hospital size, and cancer specialization*

Hospital factors	*No. of hospitals*	*Patients*	*Actual length of stay (d)**	*Actual length of stay (d) – expected length of stay (d)†*	*Actual hospital charges**	*Actual hospital charges – expected hospital charges†*
Cancer specialization						
National cancer institutions	12	310	14.9 (14.1–15.8)	2.3 (1.1–3.6)	$42,113 ($39,097–$45,356)	$15,812 ($11,872–$19,751)
Community hospitals	13	30	20.2 (16.1–25.6)	7.0 (2.1–11.9)	$67,535 ($50,945–$89,518)	$40,629 ($24,978–$56,280)
P value			.002	NS	<.005	<.05
Esophagectomy volume						
≥5 cases/y	5	266	14.7 (13.9–15.6)	2.5 (1.2–3.8)	$39,867 ($36,839–$43,144)	$14,752 ($10,679–$18,825)
<5 cases/y	20	74	17.7 (15.6–20.2)	3.8 (0.7–6.8)	$62,094 ($52,976–$72,773)	$29,679 ($19,764–$39,594)
P value			.006	NS	<.005	<.05
Total operative volume						
≥3333 cases/y	10	263	14.8 (13.9–15.7)	2.4 (1.1–3.7)	$40,380 ($37,291–$43,726)	$14,334 ($10,200–$18,469)
<3333 cases/y	15	77	17.4 (15.2–19.8)	4.0 (1.0–7.0)	$58,413 ($49,726–$68,631)	$30,524 ($21,072–$39,976)
P value			.017	NS	<.005	<.05
Hospital size						
≥600 beds	12	176	14.1 (13.0–15.2)	1.9 (0.3–3.5)	$38,300 ($34,341–$42,715)	$15,844 ($10,688–$21,006)
<600 beds	13	164	16.8 (15.6–18.2)	3.7 (1.9–5.6)	$50,833 ($46,360–$55,731)	$20,315 ($14,572–$26,058)
P value			<.05	NS	<.05	NS

NS, Not significant.

*Mean with upper and lower 95% CI in parentheses.

†Difference of actual length of stay or hospital charges – expected length of stay or hospital charges obtained by using expected outcomes developed from the 10 million–patient database of the national HCUP survey.

with experience.[13,14] This factor may be due to several things. Hospitals that have a large census (large number of beds) or perform a large number of operations (not necessarily esophageal) often are able to purchase items in bulk at lower cost and have intensive care unit staff, equipment, and services (epidural-pain service) unavailable at smaller hospitals. Furthermore, some hospitals are specialized in oncology (national cancer institutions) and have a large experience with multidisciplinary efforts, as well as experience with careful patient selection. One study suggested that even long-term outcome is affected when patients are cared for by specialist breast surgeons rather than nonspecialists.[15] Gillis and Hole[15] noted a 16% reduction in the risk of dying and an 8% higher survival at 10 years when similar patients were cared for by oncologic specialists. Furthermore, Lee and colleagues[16] noted decreased complications and improved long-term survival when patients with lung cancer were entered at an experienced oncologic institution in an intergroup trial (RTOG92-04). Our study therefore evaluated these other factors (cancer specialization, nonesophageal operative volume, and hospital size) to determine whether they were also associated with outcome and whether improved short-term outcome translated into decreased hospital use.

We used a Medicare-provided database that assessed discharge data provided by a large number of institutions. One of the benefits of this database was that it allowed evaluation of a large number of institutions in an unbiased fashion. Although the database captured only Medicare-linked patients, the majority of patients with esophageal cancer are elderly. Begg and colleagues[9] noted with another Medicare-linked database that approximately 90% of patients over 65 years of age were captured. Additionally, these data were available not only as actual data but also as risk-stratified data in which an expected outcome was created on the basis of the patient's diagnosis, diagnosis-related group, age, sex, admission type, and associated comorbidities. The risk-stratified data allowed analysis controlled for differences in hospitals' patient populations because many tertiary referral centers have reported that their patients often have more complex disease, with an increased number of comorbidities.

The major observation of our study was that operative mortality was dramatically decreased in hospitals that specialized in cancer care and in hospitals that performed a large number of esophagectomies. Analysis of the data univariately was difficult because the same hospitals that specialized in cancer care (national cancer institutions) also tended to be the hospitals in which

a large number of esophagectomies were performed. Additionally, in our database few patients underwent esophagectomies at community hospitals, making a direct comparison difficult. Multivariate analysis was therefore performed and suggested that the true independent risk factor for operative mortality was the number of esophagectomies (odds ratio of 3.9, if performed at a low-volume center) and not the specialization of the hospital (Table III). These findings are corroborated by Begg and colleagues,[9] who noted that the operative mortality in low-volume centers was 17.3% as opposed to 3.4% in high-volume centers, although this study did not control for cancer specialization. This observation has potentially important clinical implications because it suggests that tertiary referral systems could be designed for complex oncologic procedures with low operative mortality that do not necessarily incorporate cancer specialization. The question addressed by Gillis and Hole[15] and Lee and colleagues[16] about whether cancer specialization has an effect on survival still needs to be evaluated in the setting of esophageal cancer. There also appeared to be a tendency for decreased complications in hospitals in which a large number of esophagectomies were performed (55% vs 68%, $P = .06$), although this difference was not statistically significant when severity-adjusted data were analyzed. Perhaps a more careful analysis of morbidity with a delineation of major and minor complications or a larger sample size would allow a statistical difference to be demonstrated.

It is also important to recognize that this database captured only Medicare-reimbursed esophagectomies, and we excluded all patients without malignant disease of the esophagus. In our institution Medicare-reimbursed cancer-related esophagectomies represented 37% of all esophagectomies performed. The number of esophagectomies performed per year is therefore only a relative value, and the actual threshold experience level for acceptable mortality is probably higher when Medicare- and non–Medicare–reimbursed esophagectomies for benign and malignant disease are taken into account. Additionally, as Fig 1 shows, the majority of hospitals in which esophageal operations are performed fall into the low-volume category with high overall mortality rates. Because overall survival is low in esophageal cancer (5-year survival, 20%), all attempts to minimize operative mortality must be made to realize the benefit of surgery. As with carotid endarterectomies, esophageal resection at a center without experienced surgeons may not be justifiable.[17] Further studies need to be performed to determine whether esophagectomy volume at the hospital is simply a surrogate end point for individual surgeon experience or whether this reflects the experience of the institution at taking care of these patients with complex diseases.

Table V. *Multivariate analysis of hospital charges in hospitals according to operative volume, hospital size, or cancer specialization*

Hospital factors	β *Coefficient*	*CIs*	P *value*
Hospital charges			
Cancer specialization (community hospitals)	1.18	0.87–1.60	.28
Esophagectomy volume (<5 cases/y)	1.42	1.13–1.78	.003
Total operative volume (<3333 cases/y)	1.03	0.83–1.28	.79
Hospital size (<600 beds)	1.29	1.1–1.53	.002

The second major question was whether the decreased mortality observed in high-volume centers translated into decreased hospital use or whether hospital use was determined by other factors. Many cancer centers have recently adopted multidisciplinary care centers with pathways for specific procedures in hopes of improving efficiency and decreasing hospital use, whereas large hospitals try to decrease costs by purchasing items in bulk or providing efficient multidisciplinary intensive care units. Interestingly, univariate analysis suggested that all these strategies were beneficial, with decreased hospital charges in national cancer institution hospitals, large hospitals, and hospitals that perform a large number of operations of either an esophageal or nonesophageal nature (Table IV). Multivariate analysis suggested that the most significant factors for hospital charges were not only esophagectomy volume but also size of the hospital (Table V). These findings imply that hospital charges can be affected from several directions. Decreased charges can occur with increased operative experience and improved short-term outcome, resulting in a decreased need for hospital care. Alternatively, decreased charges may be possible by centralizing care in large hospitals that can deliver services not available at smaller hospitals. Several studies have suggested that placement of an epidural catheter appeared to decrease hospital charges by reducing intensive care and hospital stays through improved pain control.[18-20] Additionally, large hospitals often have available 24-hour intensive care unit teams not present at smaller community hospitals.

With our changing patterns of health care, these observations are important. As health maintenance

organizations develop and governments seek novel modes to deliver care, it is important to recognize that certain complex surgical procedures need to be centralized in tertiary referral centers. With esophagectomies, increased experience results not only in decreased mortality but also in decreased hospital charges. A strategy emphasizing centers of excellence for esophageal resections should result in improved outcomes for the patient and decreased charges for the health care industry.

We thank Kenneth Hess, PhD, of Biomathematics and Kelly Hunt, MD, for assistance in reviewing the manuscript and Monica Contreras for preparation of the manuscript.

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Discussion

Dr Douglas E. Wood *(Seattle, Wash).* Dr Swisher, I congratulate you and your colleagues for the perseverance and patience that I am sure must have been necessary to penetrate the Medicare database in the HCUP. Physicians involved in outcomes research recognize that the layers of bureaucracy one must pass to access the data are far more difficult than the data analysis itself.

One problem with these data sets is that they are fairly crude, limiting the extent of questions that can be answered, and require the formulation of a hypothesis around the available data. In this case the authors may have preferred to examine the effects of individual surgeon experience on esophagectomy outcomes but instead chose hospital volume as a source of data that was extractable from the database. Although outcomes analysis in cardiac operations examines surgeon or hospital results compared with other cardiothoracic surgeons, general thoracic outcomes compare general surgeons who are occasional operators in the chest to board-certified thoracic surgeons who dedicate their practice to thoracic operations. Dr Carolyn Reed has already shown that board certification in thoracic operations results in decreased morbidity, mortality, and cost for pulmonary resections. Similar studies in other areas have shown that increased specialization or increased volumes improve outcomes in coronary artery bypass grafting, pancreatectomy, colectomy, and breast cancer management. Outcomes research is increasingly used by the government and other insurers to determine health care policy. Because of the power of outcomes studies to influence policy decisions, it is important that we physicians take an active role in leading them, as Dr Swisher and his colleagues have done.

Dr Swisher, I have two questions about your study. I was puzzled by your choosing a volume of less than 5 esophagec-

tomies per year as the definition of a low-volume hospital. That certainly seems very low and may artificially support your results. On what basis did you choose this number, and have you done this same analysis with a different threshold, for example, 20 esophagectomies per year?

Dr Swisher. As you said, the Medicare database is a difficult system to work within, and one has to accept that the Medicare database is only picking up the Medicare esophagectomies. At our institution that was 40% of the patients undergoing esophagectomy. Five is therefore only a relative number, and the actual acceptable threshold is more on the order of 10 to 15 esophagectomies per year. We chose the number 5 because of the recent study published in *JAMA* by Begg and colleagues, in which there was significant reduction across the board when Medicare esophagectomies fell below 5 per year. We found that the mortality rate continues to fall as the number of esophagectomies increase so that hospitals that perform 25 or more Medicare esophagectomies per year have a mortality rate of only 2%.

Dr Wood. Second, do you think that the measurement of hospital esophagectomy volume is actually a surrogate for individual surgeon esophagectomy experience and that it is the surgeon's experience more than the institution's that determines the results? Is there a way that we can ask this same question but using surgeon volumes of esophagectomy as the variable?

Dr Swisher. That is a very interesting question because operative mortality is based on a variety of things. It is based on the technical experience and ability of the surgeon, but it is also based on the surrounding hospital environment. The experience of the hospital with esophageal operations and postoperative care is also important. It is probably not just the volume of the individual surgeon that is important. We are now evaluating the importance of individual surgeon volume by looking within our institution to see whether there are differences within surgeons related to volume. This study would potentially answer that question because it would look at individual surgical volume in the same hospital environment.

Dr Wood. Your article is very valuable. It supports our impressions that specialization and experience provide better results at a lower cost, truly improved value in health care that must be acknowledged by credentialing bodies and those that reimburse for health care.

Dr Vaughn A. Starnes *(Los Angeles, Calif).* Dr Swisher, I have two questions. The data suggest that, regardless of volume, the number of complications is about equal in these institutions. In point of fact, it appeared that the likelihood of death was related more to how these higher-volume institutions cared for the complications.

Dr Swisher. Again, the Medicare database is not a perfect database. Mortality is a very easy end point to obtain—you can get a yes or a no. With complications, it is much more difficult to determine an end point because there are a variety of complications, and they have not been subset into major or minor problems. In addition, the people who are coding esophagectomies and complications are not physicians and often not thoroughly trained in medicine; therefore, it is difficult to count on the quality of the reported complications. Operative mortality data are going to be very clean and very good, but the complication data are going to be a little bit more difficult to interpret. Nevertheless, your observation is very interesting and supports the view that the reduced mortality is due in part to hospital experience, as well as surgical experience.

Dr Starnes. Did the type of repair, the type of reconstruction, make a difference in outcomes, for example, stomach reconstruction versus colon reconstruction?

Dr Swisher. By using ICD-9 codes we were able to separate out whether the patients had a total esophagectomy or a partial esophagectomy. However, when we put that parameter into operative mortality in our multivariate analysis, it did not correlate with operative mortality or hospital use.

Dr Michael T. Jaklitsch *(Boston, Mass).* How should policy makers use these data? It seems that there is a dilemma here. We could try to decrease the number of esophagectomies that are being done on the community level, but that entails many problems. People have to travel hundreds of miles to have an esophagectomy. They are hundreds of miles away from family and support for 17 days, and there is a 3% chance of dying away from home. Another danger is that they will never be offered esophagectomy because of that travel distance. The alternative is to try to credential those community places. Can you envision a way to improve the quality of the noncancer centers to reduce their mortality, reduce their morbidity, and perhaps offer more operations to the community?

Dr Swisher. One of the problems with esophageal cancer is that it is a relatively rare procedure. Therefore, to get the volume needed to obtain a reduction in mortality, you really have to have centers that do it. These centers do not have to be cancer specialized, but they have to be high-volume centers. These data clearly demonstrate that it is not possible to avoid an increase in mortality in hospitals in which only an occasional esophagectomy is done. Just as in strokes with elective carotid operations, a certain number of them must be done at a given hospital to get the benefit of the operation. I think the same thing is true with esophagectomies. Regardless of the system that develops, a health maintenance organization or whatever, it has to be recognized that these rare complex oncologic procedures need to be centralized, regardless of whether a community hospital or an academic center is used. We had a problem recently in our area. Some esophagectomies were performed in the low-volume community centers and the outcomes were poor. The local physicians saw that the patients did very badly and started to give the patients definitive chemoradiation therapy rather than surgical therapy. Therefore, I think it is very important to air the fact that esophagectomies can be done with low morbidity, low mortality, and decreased costs at high-volume centers.

Dr John R. Benfield *(Los Angeles, Calif).* I am really commenting equally on your presentation and on the comments of other discussants. The fact that you got your information in a retrospective manner from the Medicare data is important. Now we need to validate your findings with prospective information. In cardiac operations we have the Society of Thoracic

Surgeons database, which to my knowledge is the best available information in the world. I am pleased to tell you that the Society of Thoracic Surgeons is now working very hard to create a general thoracic surgical database that would include esophagectomy. This will facilitate obtaining additional information of the kind that you have given us today.

Dr David Jablons *(San Francisco, Calif).* I enjoyed your article. I might have missed one comment, and I think it is important: if there is one consensus about how to manage adenocarcinomas of the gastroesophageal junction, I think it is that there is no consensus. As you mentioned, the incidence of tumor is changing rapidly, not just in esophageal cancer but in cancer of the thorax overall. It is especially critical, retrospectively and prospectively, to try to determine how to manage these patients, and to interpret is to control for the multivariate therapies. My question specifically is this: Did you look at whether these patients were receiving single-modality therapy or combined-modality therapy and was there a preponderance of one versus the other, especially at your institution or tertiary referral centers? My guess is that there was a trend toward trimodality therapy, which has increased incidences of perioperative morbidity and mortality that may make your data more significant.

Dr Swisher. Unfortunately, that is again a limitation of the Medicare database. We are not able to delineate whether patients received preoperative chemotherapy and radiation therapy. We have studied that question very closely within our own institution, as have a variety of other investigators, and we have not been able to see any increased operative mortality or morbidity with trimodality therapy when performed in the proper setting and high-volume center. That question is probably better answered in a single institution, where all the variables can be controlled. It would be nice, but it is not available in this Medicare database.